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Ragi (*Eleusine coracana* Gaertn.)
Cultivation, Diseases and Pests

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RAGI (*Eleusine coracana* Gaertn.)

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AND

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I. Introduction

1. *Synonyms and Vernacular Names.*—*Eleusine coracana* Gaertn.—African millet, Birds foot millet, Dagussa, Finger millet, Jurracan, Korrakan and Ragi.

Synonyms.—*Cynosurus coracanus,* Linn.; *Eleusine cerealis,* Salisb.; *E. sphærosperma,* Stokes; *E. stricta,* Roxb.; *E. tocussa,* Fresen.

Vernacular names.—Bengal—*Marua*; Burma—*Satni*; Gujerat—*Bavto*; Himalayas—*Koda, Kodon, Kodra, Kutra*; Hindi—*Mandua, Marua, Ragee*; Kannada—*Ragi*; Malayalam—*Muttari*; Marathi—*Nachni, Nachri, Nagli*; Punjab—*Chalodra, Mundal.* Sanskrit—*Raga, Ragi, Rajika*; Santal—*Kode*; Sind—*Nachni Nangli*; Singhali—*Kurukkan*; Tamil—*Kapai, Kaver, Kervaragu*; Telugu—*Chodalu, Ragulu, Sodee, Soloo, Tamidelu*; Tulu—*Ragi*; U.P. and Berar—*Makra, Nanguli, Rotka*; Uriya—*Mandiya.*

2. *History.*—Ten annual or perennial grasses make up the genus of *Eleusine.* These are common in the warm regions of the Old World. One species, *E. indica,* has a wide distribution, and has been successfully introduced into the New World. *Eleusine* is derived from *Eleusis,* an old attic city sacred to Demeter the Greek deity presiding over agriculture. Nearby is the Rharian plain, where the goddess is said to have sown the first seeds of corn and taught agriculture to the people. *Coracana* is derived from *Kurukkan,* the Singhali name for this grain. The nearest ally to it in the wild state is *E. indica.*

Fresen in 1837, separated out ragi with finely striated grains as *E. tocussa*[26]. Roxburgh[25] considered forms with curved spikes as *E. coracana* and plants with straight spikes as *E. stricta.* Later, Hooker[5] brought them all under *E. coracana* Gaertn, which, he considers to be a cultivated form of the wild *E. indica* Gaertn.

Watt[30] following De Candolle, attributes a probable Indian origin to this millet, and mentions that the ancient monuments of Egypt bear no traces of its cultivation in early times; and Græco-Roman authors who knew the country, do not speak of it. It is mentioned by Sanskrit writers as *ragi* or *rajika*. The grain also finds a mention in the Bower manuscript of the 8th century.[31] Probably, ragi belongs to the group of cultivated plants like jowar, bajri and tuvar, which have an Indo-African origin.

3. *Habit.*—It is an annual grass cultivated in many parts of India for its grain, which forms the staple food of the poor. Ragi is an excellent food grain which can be raised on poor soils, and the crop is frequent on the dry and hilly parts of most districts. A certain amount is also grown under irrigation on the plains during summer.

4. *Area.*—The average area under ragi in India is as follows:—

Year ending with	*Area, in thousand acres*
1910	6,564
1915	6,641
1920	6,562
1925	6,658
1930	6,638
1935	6,716
1940	6,036
AVERAGE	6,545

Over three-fourths of this area is found in the south, the maximum concentration occurring in Mysore, where this millet forms the foremost crop in the field. Though the area in Madras is nearly as large as that in Mysore, the crop is not one of major significance. In Bombay, Bihar and Orissa, ragi is an important crop, but elsewhere is of minor significance. The area under ragi in the Provinces and States, is as follows:—

Province or State	*Acres (average)*
Mysore	2,196,600
Madras	1,885,500
Bombay	647,000
Bihar	617,500
Hyderabad	412,000
Orissa	293,000
United Provinces	249,500
Madras States	28,000
Punjab States	24,000
Baroda	20,850
Punjab	19,000
Assam	15,000
Central Provinces and Berar	11,000

Province or State	*Acres (average)*
Kashmir	6,000
Bengal	5,000
Coorg	3,500
United Provinces States	3,100
Rajputana States	500
Bombay States	500
Burma	500
Central India States	300
Sind	250
Ajmer-Merwara	140
Delhi	10
Ceylon	..

II. Cultivation and Production

5. *General Cultivation.*—The crop is raised under varying types of soil, rainfall and climate. While mainly a rainfed crop of hill-slopes and uplands, over a million acres are under irrigation in the plains. Hill types are found on laterite soils and slopes of Western Ghats, under similar localities in Ceylon, and on gravelly slopes of Himalayas upto an elevation of 8,000 ft. The crop is fed by the South-West Monsoon, the precipitation being usually over 80 inches. In Ceylon, ragi is grown when the North-East rains are received. Upland types are grown extensively over the Deccan plateau, and on the lower slopes of hills elsewhere. Soils range from medium clays to deep red loam, and light sandy types. The rainfall varies from 20 to 40 inches. Early varieties are raised during the South-West rains, but the bulk of the crop is a *Khariff* one.

Ragi land is ploughed two or three times, and harrowed once or twice. Seed is usually broadcast or drilled at the rate of 20-30 lbs. per acre, and turned under by a light plough or a brushwood harrow. Often, the fields are set with seedlings three to four weeks old. When one month old, the crop is hoed twice with an interval of about a fortnight in between, and weeded by hand later, once or twice. The crop comes to harvest after three to four and half months, and is reaped close to the ground with a sickle. The sheaves are left in the field for a few days and then stacked. The stack is opened out, and threshed after a lapse of two or three months. This millet is usually associated with subsidiary crops like *tuvar, ballar, kulthi,* cowpea, niger, castor, etc. Average yield is 8 maunds (1 md. = 82 2/7 lb.) of grain, and half a ton of straw, valued at Rs. 25. The subsidiary crops fetch an income of about Rs. 7 more. This usually leaves a margin of profit amounting to Rs. 6-7. Under irrigation, the yield of grain is twice that of the rainfed crop, but the straw is reckoned to be of very little value.

6. *Mysore.*—In Mysore, out of a net cropped area of 6·6 million acres, a third is under ragi. The important districts are found in the eastern and

central portions of the State. In the district of Bangalore, over sixty per cent. of the cultivated area is under this millet, nearly fifty in Kolar, and over forty in Tumkur and Hassan. Approximately, a lakh and fifteen thousand acres are under irrigation. The annual rainfall varies from 20–40 inches and the temperature 70–90° F. The soils differ considerably, but the typical ragi soil is an easily worked, light, ferruginous, deep red loam. Garden lands consist of fertile, dark coloured, friable soils.

The crop has two seasons—an early or *Kar* from May to August, and the main season or *Hain* from July to November or early December. Preparatory cultivation for the *kar* crop starts in April and consists of 3–4 ploughings at short intervals. The *hain* crop receives a more thorough cultivation of 4–6 ploughings at longer intervals. The fields receive a dressing of 5-10 cartloads of manure, often supplemented with tank silt and ash. Seed is either broadcast, drilled, or the fields transplanted with seedlings. In parts of Shimoga and Kadur, ragi is *hak* sown, *i.e.*, seeds are mixed with manure and are dropped inside furrows, by hand. Broadcasting, using about 30 lbs. of seed, is extensively in vogue in the *kar* area, the seed being turned in by ploughs or harrows. The subsidiary crops associated with ragi *akkadi*, are sown immediately after, in plough furrows, at intervals of 6–12 feet through the *sadde*, a hollow bamboo tube following the plough. Transplanted fields do not carry any *akkadi* rows. These subsidiary crops, in addition to providing food to the cultivator and a little extra cash, also act as a sort of crude insurance. In favourable seasons when ragi comes up well, the return from *akkadi* is small. But in unfavourable seasons, when the yield of ragi is low, the subsidiary crops which are usually more hardy and drought-resistant, bring in some return and thus partly compensate the loss in ragi. In drilling, 20 lb. is a common seed rate, the sadde for *akkadi* crops following the drill. The drills employed are of various patterns, ingenious in design and locally made. The surface is finished, by dragging a brushwood harrow *yetta* over the field, or a log of wood known as *koradu*. Sometimes, a flock of sheep is allowed to trample down the seeded plots. For transplanting, the seedlings are raised in special nurseries. A bed of 5–6 cents extent, seeded with 10 lb., provides ample seedlings to set out an acre. Seedlings, when nearly a month old, are ready for transplanting. In parts of Hassan and Tumkur where early rains are uncertain, a considerable acreage is transplanted during August. If the area to be transplanted is small, seedlings are obtained from thinning the fields seeded in July. Ragi is raised in small patches, on the Biligirirangan hills and on hills in Kankanhalli, under a shifting system of cultivation.

After three weeks the crop is hoed twice or thrice at intervals of ten days. This, in addition to weeding, thinning and providing a surface mulch, also brings the broadcast ragi into rows. An even stand is obtained by filling up gaps with thinnings, and the rows are weeded by hand once or twice. In *hak* sown fields of malnad, a harrow made up of bamboo thorns followed

by a plank are drawn over the young seedlings two to three times. In case the crop makes a rank growth before heading, the fields are lightly grazed down. In parts of Hassan, where *guni ragi* is grown (in check rows 9 inches apart), one of the cleanest systems of dry farming known is to be found. While the *kar* crop is ready for harvest in 3½ months, the *hain* sowings take a month more to ripen. The crop is harvested with sickles close to the ground, and allowed to cure for three days in wind rows. The sheaves are then made up into bundles and stacked for about two months, before threshing. Stacks of *kar* ragi are smaller, and are continually remade to prevent damage by the later rains. Threshing starts towards the end of January or February. The grain is separated by beating the sheaves, or by allowing cattle to trample over them, or by passing stone rollers. The grain is dried, winnowed, and stored for use. Grain meant for seed is often stored in *moodes* made out of twists of paddy straw.

While the irrigated crop known variously as *sasi, nati, thota* or *yedakar* ragi is grown all the year round, considerable transplantings take place during May and again in October. Seedlings are raised in heavily manured nurseries, an area of five cents sown with 8 lbs. of seed being sufficient to plant out an acre. In the early stages, the nurseries are lightly watered once a day, and thereafter twice a week. Meanwhile, land meant for planting is thoroughly prepared, and laid out into beds of convenient size (6′ × 4′). These beds may be either flat or ridged, the ridges being one foot apart. The holes are spaced six inches apart and two to three seedlings are set in each hole. The ridges are planted on both slopes. Seedlings when planted out will be three to four weeks old. Irrigation is given at intervals of about five days. The crop ripens in 3–3½ months after transplanting. The field is gone over twice or thrice, and ripe earheads are gathered by hand. These are dried, stored and threshed later. The earheads are often heaped up and allowed to ferment slightly, to facilitate the separation of grain. Ragi intended for seed is never subjected to this process of fermentation. The straw is rarely cut, but is usually grazed down, sometimes even turned under as manure for the next crop.

The numerous races of ragi grown in Mysore fall into four broad groups—*Dodda, Gidda, Kar* and *Nati.* Of these, *Doddaragi* is extensively grown, and consists of types having green or violet earheads with spikes straight and sometimes branching. It is a *hain* season crop with a duration of over 4½ months. When sowing rains are late, *doddaragi* is to a considerable extent replaced by *giddaragi.* This has a duration of 4 months and consists of types with curved spikes, green or violet. A white-grained type known as *Majjige* is grown on a small scale. Many *giddaragis* can be profitably raised under irrigation. These two groups constitute the *hain* crop, and are not suited for *kar* areas on account of their long duration. *Kar* ragi takes 3½ months to mature, and is adapted for May sowings. Earheads are green or violet, with the spikes usually curved. *Kar* ragi when

sown in the *hain* season, is caught by the later rains, and gives a poor return of both grain and straw. The *Nati* or irrigated ragi, is ready for harvest in four months, and has plump curved earheads, green or violet. Many types of *nati* ragi have branched spikes. It is considered unsuitable for dry planting, since the straw is of poor quality and low in out-turn.

There is hardly any rotation. Ragi occupies the land from season to season. In the *kar* area, which is a region of double-cropped lands, ragi is to some extent rotated with jowar, cotton and tobacco, or allowed to lie fallow in the second season. A little of the *hain* crop is alternated with cotton, groundnut, jowar, *kulthi* or castor. In wet lands, ragi is a catch crop of paddy and cane fields. Ragi is raised in gardens, either before or after a crop of potato, onion, chilly and other vegetables. Though maximum yields of as much as 40 maunds per acre are known, the average yield of the dry crop is only 8 maunds. Under irrigation, while an out-turn of 50–55 maunds is sometimes obtained, 16 maunds of grain is a fair average. Yearly production amounts to 660,500 tons.

7. *Coorg.*—Coorg has three to four thousand acres under ragi cultivation and yield being similar to that in Mysore. Production amounts to 1,100 tons.

8. *Madras.*—Of nearly two million acres under ragi in Madras, about half is under irrigation. Though grown all over the province, it never exceeds fifteen per cent. of the cropped area, even in districts, important for this millet. Salem and Vizagapatam have about 2½ lakhs of acres each, and the area in Ananthapur, Chittoor, Coimbatore, North and South Arcot varies between a lakh and two. Of states, Pudukottai has 25,000 acres and Cochin 1,800. The soils are usually red or ash coloured, light and easily workable. In parts of Ananthapur, Chittoor and Cuddapah, black and chocolate coloured soils are met with. Rainfall ranges between 20 to 40 inches, and temperature 80° to 105° F.

The dry crop has three seasons. In northern and central districts, sowings commence in May, the crop coming to harvest in August-September. The main season one is known as *Pedda-panta* or *Salu-chodi* when the bulk of the crop is sown, lasting from August-September to November-December. In the south, sowings take place from October onwards till December, the period of harvest lasting from February till May. The early crop is fed by the South-West Monsoon, and the late one by the North-East rains. The varieties grown are of early maturity, the spikes being usually curved. The *Pedda-patna* derives the benefit of both monsoons, and consists of late varieties with straight spikes. It is said to yield as much as 20 per cent. more grain than the early types with curved spikes.

Cultivation practices are similar to those described under Mysore. In dry districts like Ananthapur and Kurnool, the blade harrows—*guntaka*, replace to a large measure the work done by ploughs elsewhere. In parts of Coimbatore, Trichinopoly and Tanjore, the country plough serves as a

general purpose implement, hoes and harrows being largely dispensed with. Setting the fields with transplants is very common. Usually, the earheads are gathered first, the straw being grazed down or reaped later. In hilly regions, ragi is often grown under a shifting system of cultivation known as *Soliga*.

There are two seasons for the irrigated crop, though much is grown all the year round. The *Punasa* or hot weather crop lasts from May to August-September, and the *Pairu* or cold season one from November-December to April. The *Punasa* crop is of a larger extent than the *Pairu*. In the cold season, early varieties of 90–105 days duration *Kulla ragi* are preferred, while in the hot season, longer duration varieties *Perum ragi* are grown. Seedlings are raised in well-managed and heavily manured nurseries and planted out when about a month old. Where sheep are abundant, the garden ragi often gets the benefit of their penning. A crop of *Punasa ragi* is often raised on paddy fields with a limited or precarious supply of water. Land intended for planting is diligently prepared and laid out into beds. The bed surface may be either furrowed, flat or ridged. Flat beds are usually preferred for the cold weather crop. Two to three seedlings are set in each hole at a distance of six inches between rows, and four in the row. Sometimes, seed is broadcast into flat beds, and subsequently thinned as desired. In North and South Arcot, the spreading type of groundnut is dibbled in alternate rows of *Kulla ragi* when the latter is in earheads. In parts of Coimbatore and Salem, Cambodia cotton is often planted in *Perum ragi*, when it is nearing maturity.

The dry crop is sometimes alternated with groundnut, cotton or jowar. On double cropped lands, the other crops in the season are gingelly, jowar, other millets, coriander or gram. In garden lands ragi is grown either before or after a crop of gingelly, bajri, onion, sweet potato, chilly, tobacco, jowar, wheat, gram or cotton. Average yield of a dry crop is 8 maunds, that of the irrigated one being just over twice. Annual production amounts to 810,000 tons.

9. *Bombay.*—In Bombay, *nagli* is mostly a crop of hill slopes and uplands, and covers an area of six and a half lakhs of acres. Ratnagiri has an acreage of two lakhs, this millet occupying twenty per cent. of the cropped area. Nasik has about a lakh of acres and other districts like Belgaum, Dharwar, Kolaba, Poona, Satara and Thana, have between 30–50 thousand acres each. The crop is usually a *Khariff* one, but, in parts of Gujerat and Konkan small areas come under irrigation during summer. On ghat slopes the rainfall is usually over 100 inches, elsewhere between 30–40. The crop is raised on red loams in Karnatak, on well-drained, shallow, gravelly soils, of *Varkas* lands in Konkan, and *besar* or clayey loams in Gujerat. The temperature varies from 80–95° F. during cropping season.

Immediately after early showers, preparatory cultivation is taken up and consists of 2–4 shallow ploughings. On good level land, harrows often

follow the plough. Where slopes are steep, the entire cultivation, or a major portion of it, is done by manual labour. On hill slopes much of *nagli* is grown under *Kumri*. The land is cleared of vegetation, which is laid on the surface and burnt when dry: *rabbed*. The dry material is often supplemented by adjacent tree growth, and *harik* (*Paspalum scrobiculatum*) straw. In Kanara, ragi is often grown in *kumri* land on ridges 2–2½ feet wide and 1½ feet high. While rabbed fields receive no manure, others get a dressing of two to three cartloads of manure and ash. For the transplanted crop, the manure is applied to the holes when the seedlings are set. This is at the rate of one to two cartloads per acre for fallow land and about fifteen for land under regular cultivation. In coastal areas, fish refuse is often used as manure. On uplands, sheep folding is common.

Seed is either broadcasted or to a lesser extent drilled, but more often the fields are set with transplants. On *kumri* lands 10 lb. of seed mixed with a large quantity of ash *dalhi* is broadcast and worked in by ploughs or hand hoes. On fallow land where *nagli* is usually the first crop, or follows a crop of *kulthi*, broadcasting of seed is frequent. Drilling is common in Karnatak and parts of Gujerat. For transplanting, seedlings are raised on *rabbed* beds or in heavily manured nurseries. An area of five cents in extent sown with six pounds of seed is sufficient to plant out an acre. In Konkan, the *rabbed* nurseries are of a larger extent, *i.e.*, 12 cents seeded with ten pounds. Seedlings are planted when five to six weeks old and nine to twelve inches high. When the fields are wet after a heavy shower, the seedlings are put in holes two to three inches deep made in the mud by thursting in a pointed stick. Sometimes, the seedlings are scattered over the muddy surface so as to lie at a distance of two to four inches. *Avatni* is the term applied to this system of broadcasting the seedlings. In areas of heavy rainfall, the seedlings are merely dropped deep into plough furrows, which are about eight inches apart. In tracts where rainfall is moderate, the seedlings are carefully planted in shallow furrows, drawn by a light plough or a seed drill. On *kumri* and fallow lands, there is hardly any weed growth and little after cultivation, except for an occasional thinning or weeding by hand, if necessary. In drier regions, the crop is regularly intercultivated with bullock-drawn implements. In ghat areas where the land is moderately sloping, a plank is drawn across the field, two to three times, when the crop is young. On steep slopes, the young crop is beaten with sticks. These operations are said to promote tillering. The *halvi* or early crop ripens late in September or early in October. November is the period of harvest for the late or *garvi* crop. The earheads are gathered first, and the straw cut later, or grazed down. Otherwise, ragi is harvested as in Mysore and the stacks threshed at the time of *Holi* festival.

In Konkan, the summer crop is raised under a peculiar system of irrigation. Seed of an early variety with straight spikes is sown direct into the beds. The growing crop is splashed with water once early in the morning

and again late in the evening. As soon as the grain attains the milk stage the splashings are discontinued.

In Karnatak, ragi is cultivated as in Mysore. In Deccan *nagli* mixed with tuvar and gingelly is often alternated with jowar or bajri. On *varkas* lands, *nagli* is followed by other millets like *harik*, then niger and subsequently the fields are allowed to lie fallow. In Gujerat, *bavto* occupies the land once in three or four years and is often drilled along with *harik*, tuvar and gingelly. Average yield is ten maunds, and annual production 231,300 tons.

10. *Baroda.*—Of over twenty thousand acres under *bavto* in the State, over half the area is found in Navasari, and about a quarter in the tahsil of Baroda. Seedlings are raised in nurseries located in elevated situations, to prevent water-logging. The nurseries are seeded in July and irrigated only when rains fail. Five pounds of seed sown in three cents of nursery is adequate to plant out an acre. Seedlings are set when nearly a month old, three in a hole, the holes being spaced eight inches apart. After-care consists of two weedings after transplanting, and two to three interculturings at intervals of ten days. The rows are sometimes earthed up. After intercultures are over, a plank is drawn across the field to encourage tillering. The crop is ready before *Diwali* in October. The earheads are cut first, and the straw is either cut or grazed. *Bavto* occupies the same land once in three or four years, and falls in between *harik* and paddy in its requirements of water and soil. When the crop is taken in mixtures, two rows of *bavto* alternate with one line of *guvar*-moth mixture. *Bavto* is often drilled between rows of cotton, sometimes with a sprinkling of tuar. The yield is eleven maunds to an acre and total production 7,700 tons.

11. *Hyderabad.*—Hyderabad grows ragi to an extent of four lakhs of acres. The chief ragi areas are found in the south. Atraf-i-Balda and Mahabubnagar have about a lakh of acres each. It is also found to some extent in Gulbarga and Raichur. The mode of cultivation and yield are similar to those of adjoining tracts of Madras and Bombay. Annual outturn is 117,700 tons.

12. *Bihar.—Marua* is essentially a crop of undulating, well-drained soils, and covers an area of over six lakhs of acres. The millet is widely grown on the uplands of Bhagalpur, Darbhanga, Gaya, Hazaribagh, Muzaffarpur and Ranchi, to an extent of half to one lakh of acres in each district. To a small extent, the crop is also found in the plains. Seed is broadcast, or more frequently the fields are planted with seedlings raised in nurseries. Broadcast sowings are often mixed with summer paddy and tuvar. While sowings commence as early as in May, transplanting is done later, during July to September. The crop is known as *bhadoi* and is harvested from August onwards up to November, depending on the period of sowing, variety, nature of soil and amount of rainfall. The bulk of the crop consists of early, red grained types known as *lalka*. The late, white, *charka* is grown over a small area. Usually, the earheads are gathered and the straw allowed

to be consumed by cattle. On an average an acre produces eight maunds of grain, resulting in an annual production of 176,400 tons.

13. *Orissa.—Mandiya* is grown to an extent of nearly 3 lakhs of acres in Orissa, under conditions similar to those in Bihar. Over sixty per cent. of this area is found in the uplands of Koraput, in which district, this millet occupies fourteen per cent. of the cultivated area. Ganjam has about seventy thousand acres, and the crop is also met with to a small extent on the hills of Sambalpur. Over twenty thousand acres are found in the plains of Cuttack and Puri. Annual production amounts to 83,700 tons.

14. *United Provinces.*—About two and a half lakhs of acres are under *Mandua* in this province. The Himalayan slopes of Almora, Gharwal and Nainital have sixty-five per cent. of this area. In the plains, the districts of Gorakhpur, Pratabgarh and Rae Baraeli are of importance. On hill-slopes, the crop occupies land freshly cleared, as well as that under regular tillage. In the latter case the millet usually follows a crop of wheat harvested in April-May, the land being immediately prepared for *mandua,* as for paddy. It is usually mixed with pulses and other crops and is collectively known as *Kan.* Seed is broadcast and worked in by dragging a harrow of brushwood. Often, it is thinned out from one field and planted in another. The young crop receives two to three hoeings and a weeding later on with the *Kutala.* It is ready for harvest in October-November, when the earheads are gathered. In Nepal, there are two types, one broadcast in May-June and the other transplanted during June-July. The former is harvested in October and the latter in November. The crop is raised on soils considered to be unsuitable for wheat, paddy or *chane.*

In the plains, the millet is found around homesteads, often mixed with jowar or maize. While sometimes broadcast, the fields are usually set with transplants raised in nurseries. Transplanting commences after the outbreak of the monsoon in June or July. The crop of the plains gives a heavier return than that of hill-slopes, 8 maunds of grain being an average. Annual production is 72,200 tons.

15. *Punjab.—Mundal* is raised to an extent of forty-five thousand acres in the province and states of the Punjab. Twenty thousand of this are situated in Kangra and the hill-states of Simla. The uplands in Kapurthala have over ten thousand acres. The crop is also seen in the districts of Sialkot, Gurdaspur, Jhang and Karnal. On hill-slopes, the millet is raised on lands too poor for paddy. On better grades of soil, *mundal* follows wheat or other *rabi* crops. The fields are either broadcast in June or transplanted. Harvest is during September-October, yielding 10–12 maunds of grain to an acre. In several districts, the growing crop provides 2–3 cuttings of green fodder. In dry season, the area under this millet expands considerably. Production amounts to 15,800 tons.

16. *Rest of India.*—About fifteen thousand acres of ragi are found on the Naga Hills of Assam, and over five thousand on the hills of Darjeeling

and Chittagong in Bengal. The hill-slopes of Kashmir have over five thousand acres under this millet. The mode of cultivation and yield on these hill-slopes is much akin to *Kan* cultivation practised on the hill-slopes of the United Provinces. The uplands of Central Provinces have over ten thousand acres under this millet the crop being a *bhadoi* one, as in Bihar. In the plains of Northern India, the millet is sometimes met with as a transplanted crop of dry fields. It is usually planted in June and harvested in September. Murshidabad and Midnapur districts of Bengal and Karachi in Sind, raise crops of appreciable size. Estimated production amounts to 5,000 tons.

17. *Ceylon.—Kurukkan* is an important crop of dry regions. It is usually raised under a shifting system of cultivation known as *hena* or *chena*. The crop is generally raised as a mixture along with other millets, maize, mustard and chilly. Once the jungle growth has been cleared, the crop occupies the land only for one or two seasons. Seed is broadcast after the onset of the North-East Monsoon, and turned in by harrows or hand hoes. Subsequently little care is paid to the crop, which matures in 3–4 months. The earheads are gathered as they ripen. Average yield is four maunds. In Jaffna district, it is raised as a hot weather crop under irrigation and yields as much as 20 to 22 maunds.

18. *Burma.—Satni* is one of the minor crops, and is raised on about five hundred acres round-about Bhamo. It is highly probable, that the hill-slopes of Shan States have a considerable area under this grain.

III. Commerce

19. *Trade.*—Ragi is not mentioned in the official statistics of exports and imports of the country. Apparently, the entire produce is consumed within. In normal seasons, a small quantity is sent out from Madras to Malaya. Except in years of distress, there is hardly any internal movement of the grain between the Provinces and States. A possible exception is Mysore, which usually sends about two lakhs of maunds to the adjoining districts of Bombay and Madras. Even inside the Provinces and States, trade in ragi is comparatively little. The share of the major Provinces and States, in area, and production, is as follows:—

Total area	6·5 million Acres
Annual Production	2·1 million Tons
Value of Grain	140 million Rupees

Province or State	Per cent. of total area	Per cent. of total production	Price per maund in Rs.
Mysore	34·2	30·3	2·0*
Madras	29·8	37·2	2·5
Bombay	10·1	10·6	2·9
Bihar	9·6	8·1	2·2
Hyderbad	6·5	5·4	2·7
Orissa	4·3	3·9	2·1
United Provinces	4·0	3·3	..
Rest of India	1·5	1·2	..

* The controlled price at present is Rs. 6·2.

20. *Storage.*—The grain being very hardy, storage presents no serious difficulties. Small quantities are stored in various receptacles, in gunnies, or mearly heaped in a dry corner. Larger quantities, not immediately required for use, are stored in large receptacles, or in pits underground. The receptacles meant for storage above ground are barrel-shaped, and open at both ends. These are made of a strong framework of bamboo coated over with a paste of cow-dung and earth, with a capacity to hold as much as a ton and a half. They are placed on raised rat-proof platforms, usually a slab of stone, and covered with a lid. The underground pits known as *hagevu* in Mysore, are pot- or bottle-shaped excavations of varying dimensions with a narrow mouth. These, are usually situated in dry places. The sides and the bottom are firmly rammed and lined with straw, to prevent soaking in of underground moisture. The mouth is closed with a slab of stone, covered with earth and firmly trampled down; thus, securely sealing in the grain. These pits are constructed with such skill as to be hardly distinguishable from the surface. Some of the large-sized ones have a capacity to hold as much as ten tons. Grain stored thus has been known to keep well for a long time, as long as fifty years in Mysore.

IV. Composition and Uses

21. *Composition.*—A bushel of grain weighs 60 lbs. and one pound will contain 1½ to 2 lakhs of seeds. Coleman,[3] mentions differences in size of grain; which while not apparent to the naked vision do exist, and cause appreciable differences in the weight of grain per unit volume. The proportion of husk, which is five to six per cent. by weight, is the lowest among food grains. The composition of the grain is as follows[33]:—

Moisture	13·1%	Calcium	0·33%
Protein	7·1%	Phosphorus	0·27%
Fat	1·3%	Iron	5·4 mg.%
Mineral matter	2·2%	Calorific value for 100	
Carbohydrates	76·3%	100 gm.	345
		Calories per ounce	98

22. *Food Value.*—The presence of phosphorus and the low basic nitrogen content are the essential characteristics of *Eleusinin* of ragi.[9] In its content of cystine, tyrosine and tryptophane, it is superior to the gliadin of wheat. At a 5 per cent. level of protein intake, the digestibility and the biological value of the total proteins are 77·5 and 90·5 per cent., respectively. Sastry[27] and Ramiah[11] have shown that much variation exists in the net protein value, and in its nutritive properties between varieties of this millet. The protein content of E.C. 1540, a white-grained ragi, is as high as 14·2 per cent. The calcium content is very much higher than that of all other common cereals and millets. Though the availability of this calcium may be low, bulk for bulk ragi will supply a greater amount of available calcium than rice and other cereals. The nutritive value of a diet largely

based on rice, could be raised by replacing some of the rice by ragi.[1] The content of vitamin A is 70 Y per 100 gm. That of B_1 is 335 Y, but varies considerably from variety to variety, E.C. 1540 having as much as 700 Y.[8] The B_2 content is poor. Swaminathan[29] has observed that while ragi is good for *maintenance*, its growth-promoting virtue is rather poor. This could be ameliorated by a small supplementary intake of pulses and milk. The zinc content is 1·48 mg. in 100 gm. The iodine content of 101·4 Y per kg. is the highest of any grain.[10]

23. *Uses.*—Ragi is not very wholesome, and somewhat taxing on the stomach. The grain is inexpensive, and since a little satisfies an empty stomach, the poor reckon it as an economic grain. It enters largely into the diet of the poor and labouring classes. In South India, the grain is considered to be very sustaining, and forms a major item in the dietary of prisons. On account of its keeping quality, the grain is unsurpassed as a reserve against famine. Differences in the quality of grain have been mentioned by Yegna Narayan Aiyer.[32] The flour is coarse since the grain is ground along with the husk. This has given rise to the saying *manduva ki roti, kambal ki dhoti.* The flour is made into gruel, pudding, unleavened bread or into cakes. The roasted grain is more palatable and nutritive. A crude form of malt prepared in the household is thought of highly, and is administered to infants and invalids. Soup, *ambli* or *ambil,* served cold is considered to be a cooling beverage in summer. The green heads cut when fully ripe, and parched, are considered to be a delicacy when taken along with *gur.* A thin gruel is often given to milch cows and ailing cattle.

The grain, especially the white sort, is highly suited for the preparation of malt.[27] The diastatic activity of this malt is as good as that made out of barley. The keeping quality of ragi malt is very high. The grain also forms a suitable basis for the manufacture of farinaceous and invalid foods. A fermented liquor *bojah* or *bojali,* is prepared from the grain, in parts of Bombay. A similar preparation, distilled into a spirit or made into a kind of beer, is freely used on the slopes of the Himalayas.

The presence of husk, specially in coarsely ground flour, some times causes diarrhœa. Old grain indifferently stored in underground pits, gives rise to intestinal disorders which may prove fatal. Ragi is considered to be an astringent.

24. *Straw.*—The straw varies considerably in its composition (Sen[28] and Ramiah[12]). Average composition is as follows:—

Moisture	9·88 per cent.
Ash	12·10 „
Protein	2·19 „
Fat	2·37 „
Fibre	28·22 „
Carbohydrate	44·88 „

In regions where ragi is the prominent crop of dry fields, the straw is considered to be one of the finest and as such, is carefully conserved. In parts of Mysore, working cattle fed on it thrive well, without any addition of concentrates. The quality of straw improves on keeping, apparently due to fermentation. When carefully stacked, it remains wholesome for 4–5 years, though left in the open. Elsewhere, the quality is reckoned as being similar to that from paddy. It is sometimes fed to horses but is considered to be heating. Under irrigation, the straw turns coarse and woody, and is grazed down while standing or turned in as manure. Sometimes the straw is harvested and used as thatching material, bedding for cattle, or as fuel.

V. Crop Botany

25. *Genetics.*—The genetics of this crop is under active investigation at the Millet Station, Coimbatore. While the predominant colour of the grain is brown, white types are known, and light brown grains are mentioned by Coleman.[3] The brown colour, is found on the surface portion of the grain; and is caused by two factors operating either alone or in combination. In the absence of both the grain is white. A third factor, in association with any one of the above, produces purple colour in the plant; hence the absence of white grains in purple races.[14] Another factor, that deepens the brown colour, behaves as a simple dominant. According to Coleman,[3] white grain is associated with pale green glumes and light brown colour of the grain with yellowish brown glumes. Polyembryony has been reported.[13]

Two factors are responsible for the development of green colour in the plant. These, either alone or together, result in a normal plant. When both are absent, the seedling turns white and dies.[15] Purple colour is dominant over green. Rangaswami and his co-workers[16, 20] have resolved this purple into four distinct types. The corresponding green forms look alike, and can be only differentiated by a study of crosses and their progeny. In the unripe grain, dark green colour is dominant over light green. The depth of green is governed by a single factor.[17] The tint of dry anthers shows a differentiation in depth corresponding to the green colour of the unripe grain, and is associated with it.

According to Coleman,[3] the earheads are of three types—closed, open and branching. The closed nature of the earhead is due to a bend developed in the spikes or fingers. This bend, or curvature, is determined by a factor which causes the spikelets to be closely packed. The corresponding member causes the spikelets to be loose, the fingers straight, and the earheads open,[19, 21] Length of fingers is governed by two factors. Either of them gives a short length, both a long length, and neither a very short length. The factor for curvature, in association with the factors governing the length of fingers, result in three types of closed earheads. These are top-curved, incurved and fist-like. The corresponding open types are, long open, short open and very short open. The branching nature of spikes behaves as a

recessive and is governed by several factors (unpublished work in Mysore). Anthesis and pollination have been investigated by Coleman,[3] Gokhale,[4] and Rangaswami.[22] The flowers remain open for a very short period, just before dawn. Self-pollination is the rule. Occasional cross-pollination also occurs in nature. The length of glume is governed by three inhibitory factors.[23] All three of them give a short glume, any two a medium glume, and each or none a long glume. Two types of sterility occur in this millet.[18] The chromosome number is 18 as reported by Rau.[24] The basic number for *eleusine* is 9, and *E. coracana* is a tetraploid.[6] Several abnormalities like zebra leaves and foliation and truncation of the panicle, resulting from irradiating the seed, have been described by Krishnaswamy.[7]

26. *Classification.*—The ragis in Mysore have been classified into seven types by Coleman.[3] The basis for this classification were the colour of the glume, colour of the grain, and nature of the earhead. As it is, no satisfactory classification of this millet exists, at present. Ragi may be grouped,—

(1) On the basis of grain colour	.. ..	into brown or white;
(2) Colour of the plant	..	4 shades of purple or green;
(3) Nature of earhead	..	closed, open or branched, with sub-groups based on length or spikes.
(4) Duration of the crop	..	Early, medium, or late;
(5) Habit	.. ..	Hill, upland, or irrigated;
(6) Season	.. ..	Season of planting like May, June-July, October, etc.

27. *Economic Characters.*—Some of the characters that influence yield in this crop are reported by Coleman.[3] Types with straight spikes are on an average more prolific yielders than those with curved ones. Where the spikes are straight, the colour of the glume has no influence on the yield. Where earheads are plump, the tillering is poor, and *vice versa.* Types which develop large earheads may prove suitable for irrigation. Badami[2] has observed that varieties with small heads have thin straw, and that open-headed varieties were suited to drought conditions, while closed types were suited to moist situations, or tracts of heavy rainfall. In ragi,—

(*a*) *Yield*—bears a direct relation to duration, height and tillering capacity; and is not influenced by the size and shape of the earhead, or the number and length of fingers.

(*b*) *Tillering*—is inversely related to height of plant and size of earhead.

(*c*) *Quality of straw.*—Fineness is directly associated with tillering and is adversely influenced by height of plant and size of earhead.

(*d*) *Yield of straw*—is directly in proportion to duration, and height of plant; and

(*e*) *Maturity*—bears a broad relationship to the shape of earhead but not to its colour. Curved types are usually early maturing,

while most late varieties have open earheads. Again, early varieties usually possess short spikes, while medium and long spikes are common in later maturing forms.

28. *Improved varieties.*—H. 22 and K. 1 are two improved varieties extensively under cultivation in Mysore. H. 22 is a long duration *hain* ragi, with violet, open earheads. Besides Mysore, it is grown to a considerable extent in Salem and Chittoor districts of Madras. K. 1 is of medium duration. It has green curved heads, is adapted to *kar* sowings as well as for irrigation. Of recent introduction into the *kar* tract are: R. 0862, R. 0009 and R. 0871. R. 0862 is a very early type, profusely tillering, and has violet curved spikes. The other two are of medium duration with curved spikes, green in the former and violet in the latter. Apart from H. 22, the following are recommended for *hain* sowings: R. 0883, a *gidda* ragi with green curved fingers, and R. 0833 and R. 0870, both having the spikes violet and curved. Under irrigation are R. 0324, a violet branched type during summer, and R. 0786 with green curved spikes in other seasons. In Madras, E.C. 593 is much of a general purpose ragi. It is suited for irrigation as well as for dry conditions. In the Vizagapatam district, V. 33 and A.R. 525 are suitable for the *Pyru* crop, while for the *Punasa* season E.C. 593, A.R. 525 and B.B.L. 5 are advocated. In the dry districts at the centre, E.C. 593 and R. 32 are popular. The Tamil districts in the south prefer E.C. 593 and E.C. 3517. South Arcot and adjacent tracts find the variety E.C. 3735 well suited to local conditions. E.C. 24 is adapted to the extreme south in Tinnavelly and parts of Ramnad. The coastal regions of Bombay find the very early open panicle type B. 11 very profitable. Other improved strains are E. 31, of medium duration and A. 16, a late type. Ceylon advocates the cultivation of E. 43, which has a duration of 3½ months. About four lakhs of acres are under improved varieties in Mysore, and probably, an area of similar extent in Madras. For the whole of India, however, the area under improved strains is well inside a million acres.

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GLOSSARY

Bajri	..	*Pennisetum typhoides*, Staff and Hubbard.
Ballar	..	*Dolichos lablab* L.
Chilly	..	*Capsicum annum* L. and *C. frutescens* L.
Coriander	..	*Coriandrum sativum* L.
Cowpea	..	*Vigna unguiculata* (L.) Walp.
Gingelly	..	*Sesamum orientale* L.
Gram	..	*Cicer arietinum* L.
Groundnut	..	*Peanut, Arachis hypogœa* L.
Harik	..	*Paspalum scrobiculatum* L.
Jowar	..	*Sorghum Moench. Species.*
Kulthi	..	*Dolichos biflorus* L.
Moth	..	*Phaseolus aconitifolius* Jacq.
Mustard	..	*Brassica nigra* L. Koch.
Niger	..	*Guizotia abyssinica* Cass.
Tuvar	..	*Cajanus cajan* L. Millsp.

Diseases of Ragi (*Eleusine coracana*)

By S. V. Venkatarayan

Leaf Blight and Foot Rot (*Helminthosporium nodulosum* Berk. and Curt.)

This disease passes almost unnoticed except when it causes the ear blight which is more serious than the leaf blight or foot rot. It is particularly noticeable in years of excessive rainfall like 1916 and 1932. The entire ear-head or portions of it become blasted. The fungus belongs to a genus that has been known to cause widespread disease on wheat, barley, rye, oats, maize, jowar, paddy, sugarcane, etc.

The disease occurs on plants here and there in the field or in certain definite patches. It affects all parts of the plant, the roots, the culms, the leaf-sheaths, leaves, spikes and spikelets. On the leaves, numerous small rusty brown oval or irregular spots arise, which may later run together. Plants of all ages are attacked from seedlings to aged ones. Infected seedlings dry up, and when grown up plants are attacked the yield is reduced. Affected earheads do not mature their grain properly. The disease is spread through infected seed, stubble or soil.

The disease has been reported by Butler[1]* as the commonest disease of this crop, and according to him it occurs also in the United States and the Philippines. Coleman[4] has reported it in Mysore. He says that there is a considerable difference between the susceptibility of different varieties of ragi, and that those with green glumes appear to be much more severely attacked than those with violet glumes. Uppal, Patel and Kamat[24] have found it in the Karnatak. Venkatakrishnaiya[25] has cultivated the fungus and studied its growth under artificial conditions. He says that the fungus infects all parts of the host, both young and old. He has not noticed it on the roots. Mitra and Mehta[10] have observed the fungus on the roots and other parts of the plant. They say that the fungus occurs on ragi in Uganda. In India, they have found it in Coimbatore, Wynaad, Pusa, Chota Nagpur, Almora and Kumaon. In Pusa the fungus occurs on *Eleusine ægyptiaca*, which harbours in addition *Helminthosporium tetramera*. Mitra and Mehta[10] have observed on ragi another strain of the fungus which they call Helminthosporium C. It is somewhat similar to *H. leucostylum*. This latter fungus attacks *Eleusine indica* and *Eragrostis major*. Mitra[9] says that of these *H. nodulosum* is the most virulent. His inoculation experiments show that it can infect maize, *Setaria italica*, and *Panicum frumentaceum*, but not wheat, oats or barley. Later, he and Mehta[10] found that *H. nodulosum* will infect, in addition, *Panicum miliaceum*, *Sorghum vulgare*, *Saccharum officinarum* (sugarcane), *Pennisetum typhoideum*, *Eleusine indica* and

* Numbers refer to literature cited at the end.

E. ægyptiaca. They inoculated Helminthosporium C. to maize, *Sorghum vulgare*, *Pennisetum typhoideum*, *Panicum frumentaceum*, *Eleusine indica* and *E. ægyptiaca*. Thomas,[22] however, in inoculation experiments with *H. tetramera* from rice, *H. nodulosum* from ragi and *H. sativum* from wheat, found that the rice strain failed to produce any infection on seedlings of barley, oats, wheat, sorghum, *Pennisetum typhoides* (cumbu), ragi, tenai (*Setaria italica*), and maize. The other two strains infected all these plants except sorghum. *H. tetramera* failed to infect the leaves or earheads of ragi and wheat, while the ragi and wheat strains were capable of mutual infection. Each strain gave a high percentage of infection only in the case of the host from which it was isolated.

Nisikado[18] has described the ascigerous stage of the Helminthosporium on *Eragrostis major* from Japan as *Ophiobolus Kusanoi* n.sp. In pure cultures from single ascospores the conidial form was obtained, and conversely on rice agar from the conidial form the *Ophiobolus perithecia* were produced. Infection experiments were positive on *Eleusine indica* and *Eragrostis major*. No perfect stage has been reported from India.

Since the disease is seed-borne it may be amenable to seed treatment. But this will not prevent subsequent infection in the field on the leaves and earheads, particularly when atmospheric conditions are very favourable for the development of the fungus.

BLAST. *Piricularia* sp.

This is a fungus that has long been known on rice, but has been noted on ragi only recently. McRae[12] says that the fungus *Piricularia* sometimes occurs in epidemic form on ragi with a resulting loss of grain that may amount to 50 per cent. He has found *Piricularia* also on *Panicum repens* (a wild grass common in the rice bunds and water channels), *Setaria italica*, *Paspalum* (*Panicum*) *sanguinale*, *Triticum vulgare* and *Panicum ramosum*. Although not differing in morphological and cultural characters, their infective capacities are quite different. In cross inoculations and field observations, the strains on rice, *Panicum repens* and *Paspalum*, are restricted each to its own host, while the strains on ragi, *Setaria* and *Triticum*, are mutually infective, and will not infect the first three hosts. The behaviour of the *Panicum ramosum* strain was not studied. According to Butler and Bisby,[2] Nisikado separated the Japanese forms on *Panicum sanguinale* and *Setaria italica* as *Piricularia grisea* and *P. setariæ*, respectively.

Seedlings are more susceptible than older plants. The symptoms are very similar to those that appear on rice, *viz.*, large oval or elongated brown spots on the leaves, and a rotten neck below the earhead. The fungus appears also on the earheads with the result that the grains are improperly filled or sometimes heavily blasted. In severe cases the infection may go up to 80–90 per cent. depending upon the humidity and rainfall prevailing at the earing period.

In a pure culture of the fungus from the earheads, Venkatarayan[26] found, unlike in *Piricularia oryzæ*, a prominent grey colour of the mycelium and spores. The conidiophores and the middle cell of the conidium were highly coloured while the two end cells were comparatively lightly coloured. The fungus formed dark-coloured chlamydospores (vegetative resting spores) in culture. These have also been noticed in Japan and, if they occur under natural conditions, will serve to tide the fungus over the hot weather.

In inoculation experiments Thomas[22] found that the ragi strain fails to infect paddy and ginger, but infects wheat, barley and oats quite readily. He[23] later found that the strains from rice and *Panicum repens* would each infect only its own host, and the strains from ragi and *Setaria italica* would both not infect rice or *Panicum repens*, but was each capable of infecting wounded leaves of the other host.

Thomas[22] studied the varietal resistance of fifteen varieties of ragi by inoculating seedlings one to two weeks old. None was resistant, all showing heavy infection. E.C. 155 was the least susceptible[23] with an infection of 24 per cent. and 28 per cent., during the period of heaviest infection, whereas the other varieties showed 59 to 89 per cent. In relation to time of sowing no earhead infection was observed in crops sown each month from 20th November to 20th June, the infection was moderate in October sown crop harvested in February, and heavy in July and August sowings harvested from the end of October to the middle of December.

Smut. *Ustilago eleusinis* Kulkarni

This disease is mentioned and pictured by Coleman[4] as occurring in Mysore. Kulkarni[5] collected the fungus at Malkapur, Kolhapur State, in October 1918, and later from parts of Bombay. He described it as a new species of smut under the above name in 1922. The disease occurs in the grains, scattered here and there along the spike. The ovaries are converted into enlarged sacs containing the sooty spores of the fungus. The ovary wall remains uninjured. The sacs or sori are roundish or mostly long, 3–15 mm. in longest diameter, greenish at first, and at maturity turning deep brown or dirty black. The spores are roundish, and dark brown to black. Kulkarni described them as having spiny walls, but Mundkur[11] examining the same authentic specimens saw that they had a rough and minutely pitted epispore, with a rather uneven margin which, he concluded, Kulkarni mistook for spines. Mundkur mentions that a smut on ragi collected by McDonald at Nairobi, Kenya, in 1936, agrees with this fungus, except that its spores have a wider range of size and a larger mean, these being 8–14 μ and 10·4 μ respectively, instead of 7–11 μ and 9·6 μ for *U. eleusinis*. Sydow's *U. eleusines* on *Eleusine indica* from China which affects the culms and whose spores are echinulate and of smaller diameter than those of the foregoing is, according to Mundkur, presumably a different species, and the specific name is not valid, having been already used by Kulkarni for his fungus.

Kulkarni says that the disease is seed-borne, and amenable to copper sulphate seed treatment like the smut on jola (sorghum). Narasimhan[16] reports that experiments on seed treatment in Mysore did not prevent the smut. Similarly McRae[13] says that field experiments indicate that this smut is not seed-borne, and consequently seed disinfection with copper sulphate is useless. Experiments conducted at a later time in Mysore by way of artificially infecting seed before sowing failed to induce smut. Infecting the flowers with spores, spraying them with sporidial suspensions and injecting sporidial and spore suspensions into seedlings with a hypodermic syringe or with entomological pins all failed to bring about infection. The manner of spread of the disease is a mystery. Fortunately the loss due to the disease is not great.

Damage in Store. *Heterosporium* sp.

Ragi is a grain particularly adapted for storage. Coleman[4] says that it is not usual to sell the new ragi as a precaution against a possible failure of crops in the subsequent season, and that a good harvest sets free only the ragi of the previous year. The grain is stored in underground pits or *hagevus* of various sizes, up to about 15 feet in diameter, and 10 feet deep with a narrow opening just wide enough to let a man down a ladder. The pits are cleaned well, and lined heavily with straw or fine chaff before filling in the grain. The ragi is covered with straw and the mouth closed with slabs and earth. *Hagevus* are usually located on high ground, so that water does not soak in. Notwithstanding this the lower layer frequently ferments and has a dark colour and musty odour, and when taken out resembles cakes of manure which have been "fire fanged". In damp-proof *hagevus* it has been known to keep for twenty to forty or even fifty years.

Narasimhan[17] says that since a long time the medical profession has had reports of intestinal disorders with vomiting and purging in persons consuming old ragi from *hagevus*. From such affected ragi he obtained a fungus called Heterosporium. He also found, but not in such abundance, a Gram positive bacterium. The rôle of the fungus or the bacterium or both in producing intestinal disorders has not been determined. Yegna Narayan Aiyer[27] says that deaths are reported to have taken place as the result of having eaten grain from some pits, which are considered to be due to ptomaine poisoning. Similar disorders have been produced by consuming old wheat flour. Scabby barley attacked by *Gibberella saubinetii* fed to pigs in Iowa produced nausea in them with vomiting and a subsequent decrease in their weight. The affected barley contains an emetic which is probably responsible for the trouble.

Green Ear Disease. *Sclerospora* sp.

An unidentified species of Sclerospora causing the green ear disease has been noticed in Mysore as early as 1930–31. The disease occurs sporadically in the field. It has been noticed both in the early or *kar* and late or *hain*

varieties. The growth of the plant is checked, the internodes are often shortened, and the leaves arise close together presenting a bunchy appearance. There is no leaf-shredding associated with similar diseases on other crops. The most characteristic symptom is in the earheads, where the floral parts are turned into green leafy structures, whence the popular name for the disease. The affected plants do not set seed. The damage is not great.

The fungus belongs to a genus that has been known to cause destructive diseases of jola (sorghum), maize, sugarcane, *Pennisetum typhoideum* (sajje or bajra), *Setaria italica* and various other crops in Europe, America, Japan, Netherlands East Indies and the Philippines.

Sclerotium rolfsii

This fungus has a cosmopolitan distribution, and its host range is one of the widest for fungi, it having been noticed on nearly 200 hosts. In India it has been noticed on potato, tomato, tobacco, brinjals, gingelly, cowpeas, beans, beetroot, apples, betelvine, groundnuts, paddy, sugarcane and a number of other plants. On ragi, Sundararaman[21] noticed it at Anakapalle in 1928 on wilted plants. Perhaps from the same source, McRae[14] reported it during 1929. Park[19] has found it on ragi in Ceylon. The fungus attacks the culms near the soil level. The diseased plants have a dwarfed and pale look. The fungus has a characteristic dense white, fan-shaped growth of the mycelium. After some time it forms the vegetative resting bodies or sclerotia which are aggregations of the fungus threads, whitish at first, and turning brownish later, not unlike ragi grains themselves in appearance. These serve to tide the fungus over the hot weather.

Sundararaman[21] has reported that the fungus forms aborted sporophores on onion agar cultures kept in the dark, and incubated at 37° C. for three days. Some strains form only sclerotia, while others produce sporophores under favourable conditions. This happens irrespective of the nature of the medium or of the environment like darkness or light. The aborted sporophores are formed by the germination of sclerotia. They have no stalk and the sub-hymenial layer is composed of a thin layer of tissue, and the sporophores measure from 0·3 mm. to 8 mm.

The fungus can also live in the soil. It is prolific under moist conditions. The remedy lies in clean cultivation, and attending to drainage. In severe cases watering the soil with a fungicide like Bordeaux mixture is of help; but it cannot be thought of in a crop like ragi.

Mosaic Disease

McRae[14] mentions on ragi a mottling disease closely resembling mosaic in the Vizagapatam district. This is a virus disease occurring on several crops in all parts of the world, many of them transmitted by insects, and very difficult to control. Kunkel[7] says that goose grass or *Eleusine indica* along with other grasses, is subject to mosaic disease in Hawaii. Cross-

inoculation tests have not been made by him, and it is probable that the disease is identical with that on sugarcane.

Leaf Spots

A leaf-spot disease due to an undescribed species of *Cercosporella* has been reported by Narasimhan[15] in parts of Mysore as early as 1920–21. The spots are brownish, elliptic, and bigger than those caused by Helminthosporium. The characteristic spores are produced on the spots. They are colourless, and resemble in shape the spores of Cercospora.

Another fungus that causes leaf spots is *Acrothecium lunatum* Wakker, recorded by Butler and Bisby.[2] This fungus is very nearly related to Helminthosporium. *A. lunatum* has been noticed also on the leaves of sorghum, *Setaria italica*, and *Panicum frumentaceum*, and another species of it occurs on the leaves and earheads of bajra. It is a minor disease.

Unidentified Diseases

Coleman[4] refers to a disease not due to any ascertainable fungus, but to abnormal soil conditions. He says that the ragi is stunted in growth and takes on an abnormal colour in years when the soil is excessively wet during the early period of growth, *i.e.*, July and August. In the violet glume types, the leaves and stems take on a reddish tinge, changing to deep red, but in the green glume types the discolouration is to a pale yellow. He found the damage to be not severe, and noticed a difference in the susceptibility of different varieties to the trouble. Yegna Narayan Aiyer[27] says that the disease appears on soils markedly calcareous and that the plants dry up slowly. He says that cases of plants putting out aerial adventitious roots, the phloem vessels being full of bacteria, are reported. He was probably referring to the new disease reported by Mehta and Chakravarty.[8]

What appears to be an entirely different disease has been observed by Mehta and Chakravarty[8] at Benares in a plot with defective drainage. They say that the soil at Benares is known to be slightly alkaline in reaction. The plants were stunted in growth, and with a pale and tufted appearance due to the suppression of the apical growth and formation of numerous lateral shoots from the upper nodes. They have noted the formation of a plenty of glistening white, usually unbranched adventitious roots from all around the nodes, even from those near the apex. The attacked plants did not form fertile shoots, or if they did, the shoots were sterile. The internodes were short, and there was normal tillering and normal length of life. Many of the older, and later the younger leaves turned brown, and at a late stage of the disease the culms also became brownish in patches and slimy to the touch. Although *Piricularia* spp. were isolated from numerous leaf-spots of young plants, microscopic examination showed that the phloem tissues of the root and stem were discoloured, and bacteria were present in the intercellular spaces, rarely in the cells. The exact cause of the disease was not determined.

A certain amount of sterility occurs in ragi. Rangaswami Ayyangar[20] says that chronic sterility results in complete failure to set seed, although the plants grow vigorously and put forth numerous earheads. The anthers are full of viable pollen and the stigmas receptive. The anthers fail to dehisce, or a disintegrated mass of agglutinated pollen devoid of contents is produced. In both cases a few stray grains develop " to keep the race going". Normal dehiscence and free pollen are produced by two separate dominant factors, and their absence results in sterility.

Phanerogamic or Flowering Parasite. *Striga lutea*

Striga is a higher flowering plant parasitizing the roots of ragi, jola (Sorghum), maize, bajra, paddy, sugarcane and pasture grasses (see Kumar[6]). It has its own leaves and is dependent on its host for water and mineral salts. There are four species of Striga in India. The seeds are very minute, and easily distributed by wind. They rarely germinate in the absence of a host plant. In Mysore the pest has been noticed as early as 1916–17 by Coleman.[3] He[4] says that early sowing of ragi is advantageous in that the ragi matures its heads before the Striga ripens its fruits, and that as the land is ploughed soon after harvest the Striga is uprooted before it can shed its seeds. Hence its spread is checked, though unconsciously.

Striga attacks both the dry and irrigated ragi. Weeding it out, if done systematically, might be of some help. Spraying with chemicals like ferrous sulphate, or sprinkling powdered copper sulphate on the ground as soon as Striga appears has had some success. Cultivation of trap crops, rotation with crops not affected by Striga, and the development of Striga-resistant varieties alone can be of any use. Such resistant varieties are known in the case of sorghum, and probably they exist in ragi.

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Insects Affecting Ragi in Mysore

(Contribution from the Entomology Section)

It is somewhat peculiar to Ragi (and Jola) in general that the insects affecting it in a pest form occur in a cycle continuously for several seasons at intervals of a few years in different parts of the State, fortunately, one pest at a time characteristic to any particular region. During certain years and in many localities, ragi remains almost entirely unaffected by insect pests of a serious nature.

Ragi under irrigation, however, is subject to the attack of a two or three species of insects that occur during successive seasons; but even so, the attack is comparatively mild except under very extraordinary conditions.

The insects dealt with here are those most commonly occurring in Mysore.

1. *Amsacta albistriga M.*

Popular name .. Red-headed hairy caterpillar
Vernacular name .. Korihula—Kamblihula

Popularly called the red-headed Kamblihula, on account of the caterpillar possessing stiff, bristly, black hairs on its body, this insect appears periodically between May-July in Chitaldrug and Shimoga districts and between July-September in Kolar District. It appeared continuously in a serious form between the years 1918–23 and 1934–37 in Chitaldrug and Shimoga districts and between 1923–30 in Kolar District. Although the pest has subsequently been noticed in these areas, there has been a considerable decrease in the incidence presumably due to the intensive large-scale control operations launched against it year after year whenever it was found to be severe.

Adult.—The adult moth is medium-sized with cream-coloured wings showing conspicuous characteristic irregular and dark markings on them; is very sluggish.

Egg.—The eggs are laid in batches of 100 or more; they are spherical and cream coloured and are attached to the leaves or the stalks of food plants. Each female moth lays about 1,000 eggs.

Caterpillar.—Just-hatched caterpillars are gregarious, gradually spreading out as they grow in size. The full-grown caterpillar is about 2½″ to 3″ in length, cylindrical with dark brown body and numerous stiff dark hairs and a distinct reddish brown head. It is very active and is a voracious feeder.

Pupa.—Full-grown caterpillars pupate inside the soil in an oval, slightly cylindrical reddish brown pupal case. The pupal period extends over a period of 9 to 10 months.

Control.—The sluggish and conspicuous parent moths are very easily seen as they emerge out and rest on the surface of soil in the fields early in

the mornings and evenings. During the years of the outbreak of the pest, school children (with the co-operation of the Education Department) were taught to spot out and collect the moths in the fields and were paid at the rate of 1 anna per 100 moths picked. This method of large-scale collection and destruction of the pest in the adult condition minimised or entirely prevented egg-laying; the damage to the standing crops and the incidence of the pest in the succeeding seasons, was thus considerably reduced. In the affected areas several panchayats liberally contributed money for the purpose of distribution among village children.

To some extent the moths are attracted to bright light on dark nights. In nature large numbers of caterpillars are seen to die from the attacks of a Braconid parasite and a fungal disease.

2. *Diacrisia obliqua.*—

Popular name .. Black-headed hairy caterpillar.

This insect has been encountered in various localities in Bangalore, Mysore, Hassan and Kolar Districts in a serious form, once in 4 or 5 years, generally from August to December.

Adult.—The adult moth is medium sized with pinkish and spotted wings and pinkish dark crossed abdomen.

Egg.—The eggs are laid in large numbers in batches on leaves.

Caterpillar.—The full-grown caterpillar measures about $2\frac{1}{2}''$ in length, is stout, cylindrical with a dark-brown body possessing numerous blackish hairs and a distinct dark coloured head. It is a voracious feeder and is very active.

Pupa.—Pupation takes place in leaf-folds. The caterpillar webs a loose, hairy cocoon and pupates in a brown pupal case.

Control.—Isolating the affected plot by trenching checks the spread of the pest to healthy crops; flooding the plot (wherever water is available) will wash out the insects. Broadcasting fresh blades of ragi dipped in calcium arsenate solution in plots and on borders in the evenings will poison numbers of caterpillars.

In Mysore the caterpillars are parasitised by a tachinid fly (*Sturmia incospicuella*) and a Braconid wasp (*Apanteles creatonota*).

3. *Cirphis unipuncta.*—

Popular name .. Army worm.

The insect was noticed in a pest form in Kolar, Bangalore and Tumkur districts in the year 1928. Since then it is seen to appear in a sporadic form once in 4 or 5 years. It is generally found in the field during the months September to December. The caterpillars hide among clods of earth and fallen foliage during the hotter parts of the day and emerge out later and climb on the plant and cause very serious damage to the crop.

Adult.—The adult is a medium-sized moth with darkish grey wings having faint patterns.

Egg.—The eggs are laid in batches on leaves. They are spherical, and creamy yellow in colour.

Caterpillar.—The full-grown caterpillar is about $1\frac{1}{4}$" to $1\frac{1}{2}$" in length, smooth, cylindrical and possesses distinct brownish wavy lines on the sides of the body. Large numbers of this caterpillar move together from field to field and cross the roadway.

Pupa.—Pupation takes place inside the soil in a brownish pupal case.

Control.—Flooding the affected nursery and the field plots, where possible, and sweeping away the caterpillars. Trenching all round the affected plots to prevent migration of caterpillars on to healthy crop. Broadcasting in the affected plots in the evenings a bait consisting of bran, calcium arsenate and molasses.

4. *Laphygma exigua.*—

Popular name .. Cut worm.

Adult.—The adult is a medium to large-sized dull yellowish-grey moth with complicated patterns on the forewings.

Egg.—The eggs are spherical and are laid on the lower surface of the leaves.

Caterpillar.—The caterpillar is smooth, cylindrical, brownish-green to dark-brown in colour with white lines on the sides. The full-grown caterpillar measures about 1" to $1\frac{1}{4}$" in length and has the habit of curling sharply when touched. It hides just underneath the soil about the roots and often cuts the seedlings at the base, coming out after dark.

Pupa.—Pupation takes place just underneath the soil in a darkish brown case.

Control.—Same as for Army worm.

5. *Colemania sphenareoides.*—

Popular name .. Deccan Grasshopper.
Vernacular name .. Kuduremuti Jitte.

Ragi grown amidst jola in some parts of Chitaldrug and Shimoga districts is subject to severe damage by the Deccan grasshopper. The pest was noticed for the first time in Mysore State in the year 1909. It attained serious proportions in the years 1925-29. Between the years 1925-38, the pest has appeared either in a mild or serious form. But since 1939 (upto 1945) this has broken out in a serious form in new areas in Chitaldrug District.

The grasshopper remains in the fields from middle of July to middle of November.

Adult.—The adult is a wingless grasshopper about $1\frac{1}{2}$" to $1\frac{3}{4}$" in length with a yellowish green body with distinct yellow lines on the sides.

Egg.—Eggs are oval, brownish and are laid in clusters in cylindrical holes in the soil on the bunds adjoining the fields in November-December. They remain in the same condition for over a period of 7 months.

Nymphs.—These resemble the adults in all external characters except in size. They are very active damaging the young seedlings and tender earheads. The nymphs are gregarious for sometime after hatching, living on the bunds and occasionally hopping into the field. After the third month they remain mostly in the field eating away the crop.

Control.—(1) Plough the bunds where possible in the early part of summer season to expose the eggs to the sun.

(2) Dust the bund with sodium silicofluoride at the time of hatching of the nymphs in July-August.

(3) Collect the hoppers in the middle of the season by means of hand nets, hopper-bags and hopper-dozers.

Since 1940 a regular control campaign against the pest in Chitaldrug and Shimoga districts is undertaken. The second and third methods of control are advocated and actually put into practice. A special staff is appointed during the season for this work and they demonstrate the methods under the direct supervision of trained men belonging to the Department. Though there is seen a considerable decrease in the incidence of the pest from year to year in the treated areas, yet the pest is making its appearance in new areas in Chitaldrug District.

The ryots in the affected areas have evinced great interest and enthusiasm in the eradication of the pest by adopting the control measures. With the co-operation of the Revenue Department, it has been possible to get hopper-bags stitched out of panchayat funds for use in the affected areas.

6. *Plusia* Sp.—

Popular name .. Looper caterpillar of ragi.

Since 1943, this insect has appeared in a pest form in some parts of Mandya and Tumkur districts. They seem to attack irrigated ragi more frequently than the ordinary ragi. The pest appears in the fields in the months of November-December.

Adult.—The adult is a fairly big-sized dirty brownish moth with conspicuous patterns of white and brown markings on the forewings.

Egg.—

Caterpillar.—The caterpillar is about $1\frac{1}{4}''$ to $1\frac{1}{2}''$ in length, possesses a greenish grey body with small wart-like tubercles on the body. It feeds on the blades of ragi, cuts the same and lives under the shelter.

Pupa.—Pupation takes place in the fold of blades inside a dirty white silken cocoon.

Control.—Hand-picking of the caterpillars as they are easily seen on the plants. In nature the caterpillars are killed and fed upon by the larvæ of a carabid beetle.

In addition to the important pests noted above the following insects have been encountered damaging ragi in the fields, but none of the latter has assumed serious form to be reckoned as a pest.

(*a*) *Sesamia inferens* .. (Ragi pink shoot-borer)
(*b*) *Saluria inficita* .. (Ragi white shoot-borer)
(*c*) *Marasmia trapezalis* .. (Ragi leaf-roller)

Ragi in storage is sometimes affected by a beetle (*Alphitobius* Sp.), which, however, is not very serious. A one-inch layer of sand on the top surface of grain in cellars or in bins, will make the adult beetles come out on to the sand layer, whence they are unable to reach the grain again.

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